The water regime of dwarf planet (1) Ceres

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The traditional view of minor bodies in the (inner) Solar System is that they are split into icy comets and rocky asteroids. However this has been challenged by recent results, such as the discovery of comets on asteroidal orbits in the outer asteroid belt (between Mars and Jupiter)[1] and the detection of water ice frost on the surface of asteroid (24) Themis[2]. The discovery of water ice on the surface of asteroids has profound implications for how the Solar System formed, and challenges our ideas about the stability of ice in the inner Solar System. The study of volatiles in the asteroid belt places strong constraints on the temperature and composition distribution in the proto-planetary disk,and on possible sources of terrestrial water, and strongly constrains formation models of the early Solar System.

Water may have played a significant role in the evolution of Ceres. Despite the mostly featureless spectrum of Ceres in the visible and near-infrared (NIR), the weak but mysterious absorption features in the 3-5 µm region have been repeatedly interpreted as water ice frost or hydrated silicates[3,4]. Note that all those possible compositions require the existence of water for their origins. The thermal evolution model of Ceres[5] suggested liquid water in the mantle in the past and perhaps even today. The HST images[6] and NIR observations of Ceres[7,8] showed a remarkably homogeneous surface of Ceres, possibly a consequence of relatively recent or even current global scale resurfacing driven by liquid-phase activity and/or volatile sublimation and mass transport cannot be completely ruled out[9].

While the results of surface spectra are ambiguous, detections of water vapour or its dissociation products around Ceres are a clear proof of a wet Ceres. Theoretical studies[10,11] suggested that water ice could remain stable at shallow depths over the age of the solar system on MBAs. Ref.[12] predicted continuous replenishing of water from the interior of Ceres and a possible water sublimation rate of 10^{24} to 10^{25} molecules/s. As the largest MBA and a dwarf planet, Ceres accounts for ~1/4 of the total mass in the main belt, and has a much larger surface area than any single small main-belt comet. In 1992, a 3 sigma detection of OH was reported by [13] based on IUE observations. A second observation did not result in a discovery. Ref.[14] tried to confirm the detection by [13] with VLT/UVES, but they did not succeed, in spite of the higher sensitivity of their observation.

We will report on observation of Ceres we performed on Nov. 2011, Oct. 2012 and March 2013 with the ESA Herschel Space Observatory[15]. We used the Heterodyne Instrument for the Far Infrared (HIFI)[16] to search for the water ground state line at 557 GHz.

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